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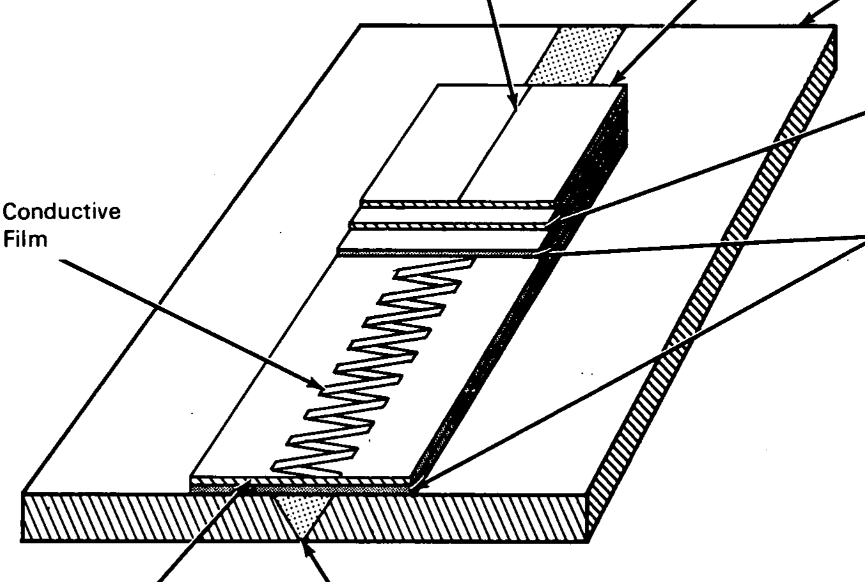
Capacitive System Detects and Locates Fluid Leaks



The problem:

To design a system that will automatically detect and locate minute leaks through seams (e.g., weld joints) in large fluid-storage tanks and pipelines which may be covered with thermal insulation or are otherwise inaccessible to direct visual inspection or probing. The monitoring system must not depend on the use of tracers, which would contaminate the fluid, or electrically conductive elements, which would not be safe to apply on the walls of tanks in which gaseous or liquid fuels are stored. Neither of these systems indicate the precise location of a leak without further testing.

The solution:

An electronic monitoring system employing a capacitive tape sensing element that is adhesively bonded over seams where fluid leaks are likely to occur.

How it's done:

The tape consists of an impermeable dielectric strip on which an electrically conductive film is deposited.

(continued overleaf)

The undersurface of the tape is adhesively bonded over the weld area. The conductive film in contact with one surface of the dielectric tape, and the metal surface of the weld and adjacent portions of the tank wall in contact with the undersurface of the tape constitute the plates of a capacitor having a known capacitance per unit length. The (stretch and tear) strengths of the conductive film and dielectric tape are appreciably less than the peel resistance of the adhesive bond. The adhesive thus forms a gastight seal over the metal surface, allowing any gas that may escape from a leak to pass only into the interface between the adhesive and the underside of the dielectric tape.

When a leak develops at any point under the tape, the escaping gas will exert sufficient pressure to stretch or tear the dielectric tape, which, in turn, will cause the conductive film to rupture at that point, thereby reducing the capacitance of the system. Since the capacitance is directly proportional to the plate area (constant width x variable length) of the capacitor, a precise determination of the leak location can be readily made by measuring the capacitance change with conventional circuitry. Leads from the readout circuitry are connected to the weld and conductive film at one end of the tape sensor system.

An overlay is adhesively bonded over the conductive film to protect it from damage. A grounded conductive film may be secured (adhesively bonded, vacuum-deposited, or applied as a coating) to the overlay and electrically connected to the weld seam. This second film will provide greater detection sensitivity by increasing the effective capacitor plate area. This film will also shield the capacitor from stray electromagnetic fields. A longitudinal slit through the conductive film and the overlay can be provided to permit the escape of any trapped gas beneath the overlay.

Tests were conducted with a detection system using a composite sensing strip constructed of the following materials: 0.002″ x 0.5″ polytetrafluoroethylene, printed conductive film consisting of colloidal silver in a silicone resin base, silicone rubber base adhesives, slitted overlays consisting of 0.005″ polyethylene terephthalate, and a vacuum-deposited (grounded) conductive film. Leaks of approximately 0.01 cc per second through an aluminum plate pressurized at 5 psig were rapidly detected and located by this system.

Notes:

1. Electrically nonconducting seams can be tested for leaks by using the outermost conductive film (instead of a metal weld surface) as the second plate of the capacitor. A second capacitor plate can also be formed by interleaving a second printed conductive film between the dielectrics.
2. By connecting several points on the printed conductor to the readout circuit, the system will simultaneously detect and locate any leaks that may occur at these points along the seam.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10099

Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquires concerning license rights should be made to NASA, Code GP, Washington, D.C., 20546.

Source: North American Aviation, Inc.,
under contract to
Marshall Space Flight Center
(M-FS-478)